

## METHOD AND APPARATUS FOR CONTROLLING A SECONDARY AIR STREAM IN AN INTERNAL COMBUSTION ENGINE

### BACKGROUND OF THE INVENTION

**[0001]** The invention relates to a method and a apparatus for controlling a secondary air stream in an internal combustion engine in which engine actuation signals and sensor signals from an engine control system are evaluated in a secondary air control unit and used as control parameters for regulating the secondary air stream.

**[0002]** It is known, for example from Published German Patent Application No. DE 100 05 888 A1, to introduce a controlled secondary air stream downstream of the catalyst during the heat-up phase of the exhaust system of an internal combustion engine. The need to supply such a secondary air stream in this manner arises in the state of the art particularly in lean-burn internal combustion engines, especially in direct injection spark ignition engines equipped with nitrogen oxide storage catalytic converters.

**[0003]** In such devices after prolonged operation, the sulfur from the fuel can limit the effectiveness of the storage catalytic converter. Because sulfate deposits are reversible within certain limits, however, the engine is operated for a predetermined period of time with a rich mixture and at high exhaust temperatures to clean the storage catalytic converter. To produce this operating state, a secondary air system of the aforementioned type is used.

**[0004]** In addition to air mass sensors, the heretofore known systems primarily also use the position of the throttle valve in the intake tract of the

internal combustion engine as a control parameter for regulating the amount of secondary air.

#### SUMMARY OF THE INVENTION

[0005] Accordingly, it is an object of the present invention to provide an improved method and apparatus for regulating the introduction of a secondary air stream into the exhaust system of an internal combustion engine.

[0006] Another object of the invention is to provide a method and apparatus for regulating the introduction of a secondary air stream which enables simple control as close to real-time as possible of an optimal secondary air stream.

[0007] These and other objects are achieved in accordance with the present invention by providing a method of controlling a secondary air stream in an exhaust system of an internal combustion engine of a motor vehicle equipped with an accelerator pedal, wherein engine actuation signals and sensor signals from an engine control system are evaluated in a secondary air control unit and used as control parameters for regulating the secondary air stream, said method comprising sensing the position of the accelerator pedal, transmitting a signal representing the sensed position of the accelerator pedal to the secondary air control unit, and regulating the secondary air stream in response to the sensed position of the accelerator among other control parameters.

[0008] In accordance with a further aspect of the invention, the objects are achieved by providing an internal combustion engine for a motor vehicle equipped with an accelerator pedal, an exhaust system, means for introducing a secondary air stream into the exhaust system, and a control unit for regulating the introduction of secondary air into the exhaust system; further comprising a sensor for detecting mechanical displacement of the accelerator pedal, and means for transmitting a signal representing detected mechanical displacements of the accelerator pedal to the control

unit for regulating the introduction of secondary air into the exhaust system.

**[0009]** Prior art methods and apparatuses for controlling the introduction of a secondary air stream in the exhaust system of an internal combustion engine for a motor vehicle have utilized a control unit for evaluating actuating signals and sensor signals of the engine control and for adjusting the secondary air stream. According to the invention, the position of the accelerator pedal of the motor vehicle is advantageously evaluated as an additional sensed parameter to be included in the control by means of the control unit. For this purpose, the position of the accelerator pedal can be detected in a simple manner using suitable sensors and, in addition to being evaluated in a central engine control for a plurality of engine functions, can be supplied in parallel directly to the control unit for regulating the secondary air stream.

**[0010]** The secondary air stream feed advantageously discharges into a feed of an exhaust system disposed upstream of a catalytic converter. Here, a storage catalytic converter is further connected downstream of the catalytic converter. The downstream arrangement of such a storage catalytic converter per se is disclosed in DE 198 16 276 A1.

**[0011]** In order to regulate the secondary air stream, a position sensor is mounted on the accelerator pedal of the motor vehicle to detect the mechanical displacement of the pedal. The output signal of this position sensor is supplied to the control unit for adjusting the secondary air stream either discretely or via a vehicle-internal bus system.

**[0012]** The invention is advantageous particularly because in newer vehicles, a direct mechanical coupling of the accelerator pedal and the throttle valve in the intake tract of the internal combustions engine, e.g., by means of a Bowden cable, is frequently eliminated. With the now commonly used engine function (drive-by-wire) control systems and electronic signaling of the pedal position, there is a risk that the difference between the actual position of the accelerator pedal and the position of the throttle

valve, which typically receives its actuating signal from the engine control, becomes increasingly larger.

[0013] Consequently, the position of the accelerator pedal, which directly corresponds to what is desired by the driver, is increasingly different from the result calculated by the engine control, e.g., to control the throttle valve, because it is increasingly modified by the intervention of various control devices such as a so-called acceleration skid control or other control device.

[0014] In view of this increasingly large difference between the accelerator pedal position and the throttle valve position, the arrangement used in the method and apparatus of the present invention especially enables the earliest possible detection of, for instance, an impending drop in the manifold pressure in the intake system. This makes possible a rapid response since the signal from the accelerator pedal provides this information first.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The invention will now be described in greater detail with reference to an illustrative preferred embodiment shown in the accompanying drawing figure which is a schematic representation of a known control unit for controlling the secondary air stream in a spark ignition engine, which has been modified according to the invention.

#### DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0016] The figure shows an internal combustion engine 10 equipped with an intake tract 11 and an exhaust system 12. The intake tract comprises at least an air filter 13 and a throttle valve 14. The exhaust system is equipped with a catalytic converter 15. Downstream of the air filter 13 and upstream of the throttle valve 14 a bypass line 16 branches off, which returns to the intake tract 11 downstream of the throttle valve.

[0017] The bypass line 16 further has a turbine 18, which is driven by a bypass air stream 19. The turbine is mechanically coupled to a compressor

20 that conveys a secondary air stream 21 in a secondary air line 22. The secondary air line discharges into an exhaust manifold 23 of the exhaust system 12 upstream of the catalytic converter 15. Downstream of this catalytic converter 15 a storage catalytic converter 17 (DeNO<sub>x</sub> catalytic converter) is connected. Arrows along the lines indicate the flow direction of an intake air stream 24, the bypass air stream 19, the secondary air stream 21, and the exhaust.

[0018] The secondary air system described above is equipped with a control unit 39, which communicates with an engine control 40. In order to control of the valve, characteristic performance data is stored in the control unit 39, which makes it possible to process various measured values of the secondary air system and the engine. At least the mass rate of flow of the secondary air stream 21 by means of a sensor 42a and the throttle valve position are determined. Instead of the sensor 42a, it is also possible to provide a sensor 42c, which measures the air stream on the turbine side. The mechanical coupling between the compressor 20 and the turbine 18 can also provide information on the secondary air stream. It is also possible to use engine control information, e.g., the mass rate of flow of combustion air in the intake tract 11 measured by the sensor 42b.

[0019] The control unit 39 is simultaneously used to operate the control valve 41 and a throttle valve 38a. The control valve 41 controls the bypass air stream 19 whereas the throttle valve 38a is intended to control the effective secondary air stream. The throttle valve 38a is provided in an additional line 43 forming a bypass for the compressor 20. This makes it possible to control the effective secondary air stream by opening the throttle valve 38a and returning the compressed air.

[0020] According to the invention, the control unit 39 has an additional input for a controlled variable, which is derived from the position of a accelerator pedal 45 of the motor vehicle without processing in the engine control. A sensor 46 can be used to detect the mechanical position of the accelerator pedal 45 directly. This direct position of the accelerator pedal

45, which corresponds to the driver's intent as described in the introduction, is therefore excellently suited for control and can be used for controlling the engine in addition to the control variable obtained from the position of the throttle valve 14.

**[0021]** In addition to the inlets 23 for secondary air injection during the cold start phase, an inlet 23a is provided, which opens into the exhaust system 12 downstream of the catalytic converter 15. A control member 44 is used to connect the feed 23 or the feed 23a with the secondary air line or to disconnect it. A simultaneous connection of both feeds 23, 23a is not provided. The feed 23a for the secondary air is intended for the operating state of desulfation of the catalytic converter 15.

**[0022]** The feed 23a can also be omitted. In this case the exhaust system would be constructed only with the catalytic converter 15 as a simple 3-way cat converter while the catalytic converter 17 would be eliminated. The function of the secondary air would be limited to accelerating the heat-up phase of the catalytic converter 15 during cold start.

**[0023]** The foregoing description and examples have been set forth merely to illustrate the invention and are not intended to be limiting. Since modifications of the described embodiments incorporating the spirit and substance of the invention may occur to persons skilled in the art, the invention should be construed broadly to include all variations within the scope of the appended claims and equivalents thereof.